GREEN WALLS FOR SUSTAINABLE BUILDINGS AND CITIES: AERODYNAMIC CHARACTERISATION OF VEGETATION

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Introduction: Air pollution caused by particulate matter (PM) is an important issue in urban environments and has severe consequences for human health and economy. Green walls (GWs) (Fig. 1) can improve urban air quality by PM capture due to deposition on leaves. GWs provide several ecosystem services in cities and are more flexible to implement than e.g. trees, which take up more space and can inhibit ventilation.

Figure 1. Living Wall System (©Muurtuin.be)

Objective: In order to understand how PM interacts with GWs, firstly we need to assess **how air flows through vegetation**.

Experimental Methods:
Air flow through vegetation was approached via a simple *Darcy-Forchheimer* model:

$$\Delta P/\Delta x = - (\mu/K) \cdot q - (\rho/K1) \cdot q^2$$

where ΔP = pressure drop (Pa), Δx = length of vegetation (m), μ = viscosity (Pa.s), K = permeability (m²), K1 = inertial permeability (m), ρ = density (kg/m³) and q = flux (m/s).

Of which: $q = v \cdot \varphi$
where φ = porosity [1-(volume plant/volume plant compartment)]

Seven plant species were tested in a closed circuit wind tunnel (Fig. 2). Permeability K and inertial permeability K1 were determined from ΔP and v measurements. Important morphological leaf parameters were retrieved using additional techniques (Table 1).

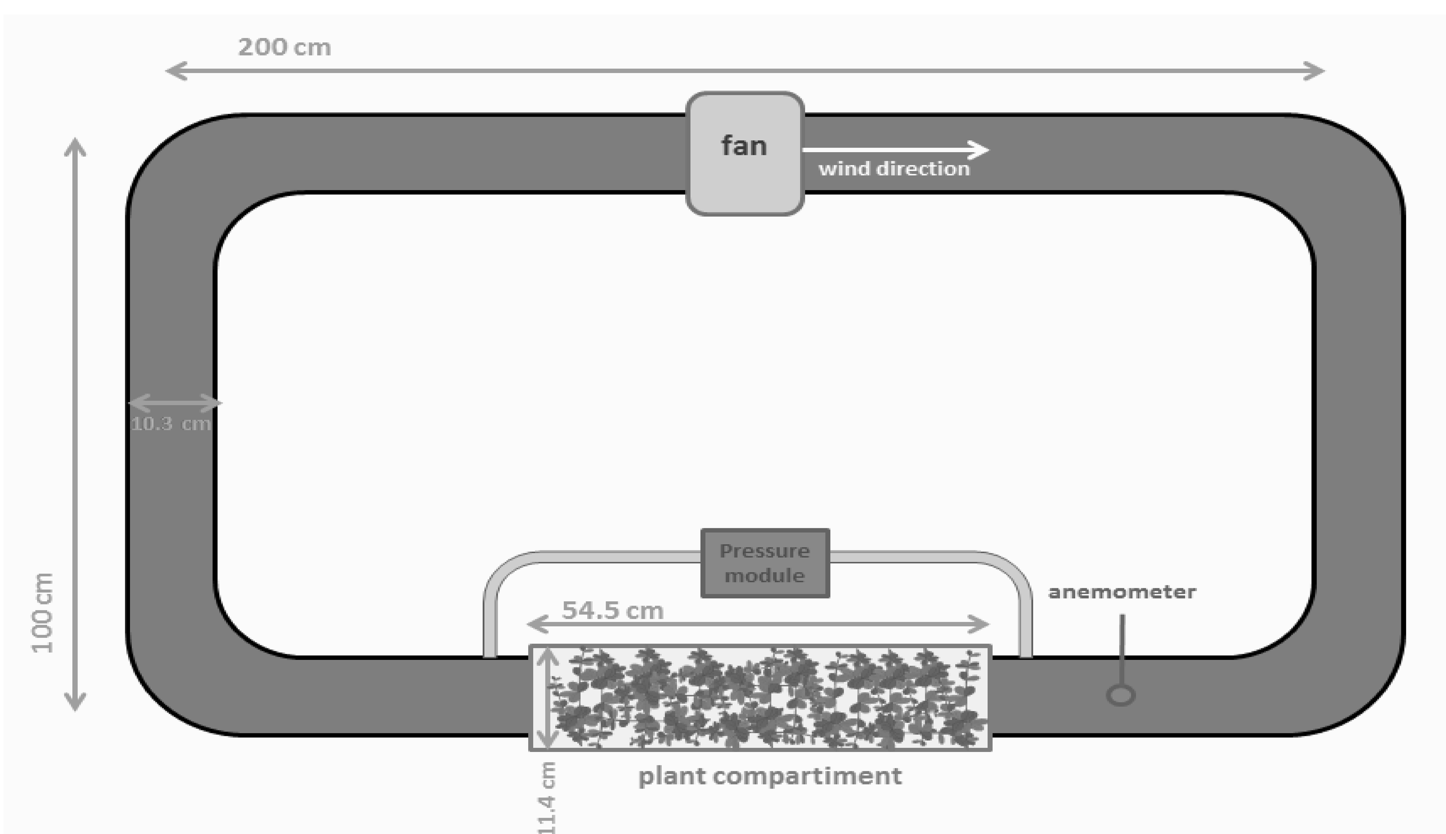

Figure 2. Wind tunnel with fan and vegetation compartment.

Table 1. Morphological parameters

Parameter	Meaning	Unit
Plant Area Density (PAD)	$A_{plant}/V_{plant\ compartment}$	m²/m³
Specific Leaf Area (SLA)	A_{leaf}/dry matter	m²/kg
Leaf Dissection Index (LDI)	perimeter leaf/$\sqrt{(A_{leaf})}$	dimensionless
Functional Leaf Size (FLS)	A_{circle}/A_{leaf}	dimensionless
Hairiness	# hairs/A_{leaf}	

COMSOL Multiphysics: A k-ω coupled turbulence model was considered including the Brinkman equation for stationary air flow through the porous vegetation section. Input parameters were φ, K and ρ/K1. The fan was modelled as an interior fan, using the fan characteristic derived from our own measurements. Simulations were performed at five different fan velocities.

First results: P and v obtained with COMSOL were plotted for each plant species (Fig. 3) and ΔP was compared to experimental results (Fig. 4).

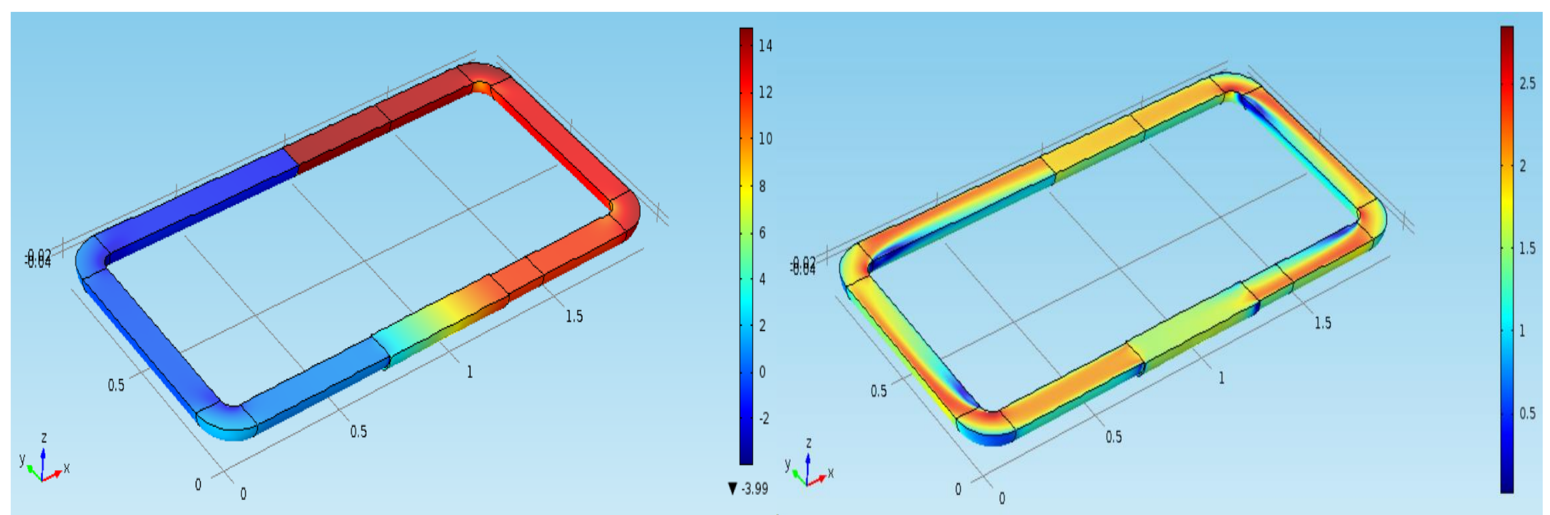

Figure 3. COMSOL results: P (left) and v (right).

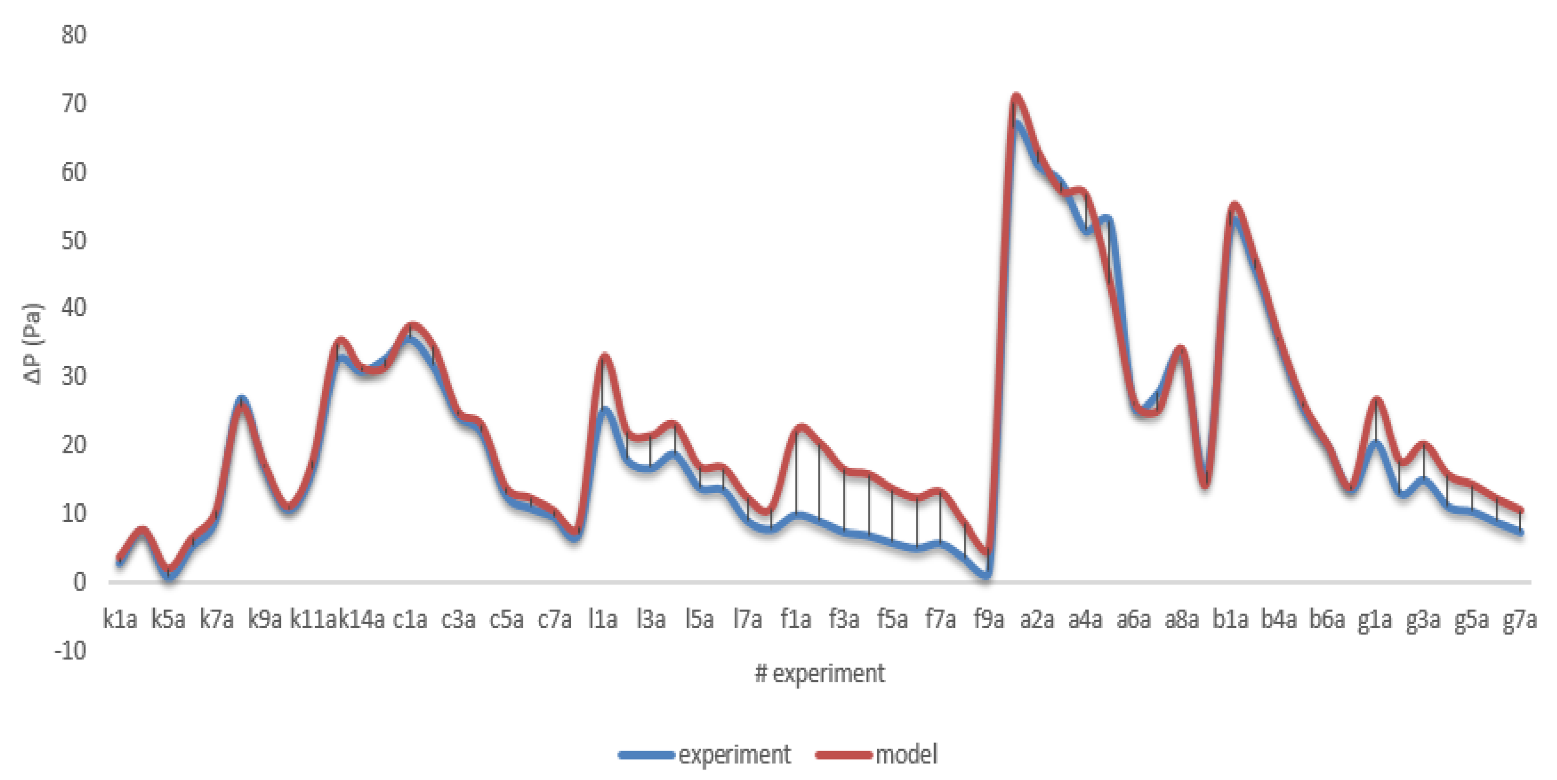

Figure 4. ΔP derived from experiments (blue) and from model (red). Each letter represents a different plant species.

These findings provide a good base for further research on PM deposition and hygrothermal effects of green walls. The model in general shows a good fit, however for some species there is an overestimation. The next step is to find the cause, by looking for correlations between morphological and aerodynamic parameters.

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